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Electric Vehicle for the Movement of Disabled People

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Abstract

Electric vehicle for the disabled is an independent mono seated vehicle that can assist to promote mobility and enhance quality of life of people, especially those who have difficulties in walking and are unable to commute to nearby places. To ensure effective mobility, users need a vehicle which fits their wheelchair correctly and meets their specific needs. In this vehicle, the frame is completely modified and incorporates a ramp at the rear end with thin iron rods attached, in the form of tracks which helps the user to get inside the vehicle using wheelchair. It also has a controller which controls the overall electrical operation of the vehicle. The speed variation is done using a hand throttle that is connected to BLDC motor via controller. The vehicle is designed for 200kg weight, 25 kmph maximum speed with length and width of the vehicle 1.5m and 0.7m respectively. A low, medium and high-speed switch is used to set the desired speed accordingly. The vehicle also has a battery indicator connected to controller so that the user is aware of the battery consumption.

Keywords: *Mono Car, Movement disable, Electric Vehicle, BLDC motor*

1.0 Introduction

Among the adults, movement disability is the major cause of functional limitations (India & States/Uts, 2011). These are especially for abled people in response to a survey, expressed their wish to lead a normal independent life (Lucas H.V., 2005), Where, they need not be dependent on their daily needs, medical emergency, etc.

To address the mobility difficulties there are various types of modified vehicles which are commercially used by the handicapped people in day to day life. The different modified vehicles which are commercially used by the handicapped people in day to day life are manually operated vehicle (MOV), engine power modified scooter (EPMS), and modified Car (MC) which help the disabled people to commute to nearby places .MOV is generally operated by the use of pedal and chain drive. It is one of the cheapest means of transport, but is difficult to use as more human effort is required to operate as compared to automated vehicles. It is also difficult to aboard such vehicles and needs a person's assistance. EPMS is a user-friendly tri-wheeled scooter which allows disabled person to commute and perform their activities without any assistance. It is compact and is the cheapest form of vehicle currently available. In EPMS, drive wheel is above the ground which makes it a failure in design and hence is a threat to safety of the user. A modified car can accommodate a physically handicapped person who has no legs. The controls such as brake, clutch and accelerator which are provided to operate in leg can be modified and given as hand controls or Joystick control. But this modification is very dangerous as the physically handicapped person driving it

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will have to control the steering wheel, put gear, and press accelerator at the same time which is very difficult. Hence such a system is not a great success (P.K. Nag, 1982). Therefore, extreme care to be taken in design, material selection, component selection, etc., to increase user friendly for the user.

In this the chassis frame is similar to ladder in design, where to keep the four long pieces parallel to each other, four long pieces of materials are joined by shorter pieces (Utkarsh Bhatnagar, 2018, Nemagoud, Vishwanath S, 2022). Whereas, a survey performed to decide the best suited battery type for electric vehicle (EV). Many types of batteries available in market, and the following batteries are popularly utilized for EV.

- Lead Acid
- Nickel-cadmium (Ni-Cd)
- Nickel Metal Hydride (Ni-MH)
- Lithium-ion etc.

Among all the batteries, lead acid batteries gained remarkable popularity because of its price and availability. Though lithium ion slowly picking up due to reliability and durability, but cost become the main barrier (VV Siman, 2016, B, Shravan Basvaraj, 2022).

This paper provides all the aspects of building an monocarp, starting from batteries, motor, drive train, power train, motor etc. There are four different types of drive train which are all-wheel drive (AWD), front wheel drive (FWD), rear wheel drive (RWD), and 4-wheel drive (4WD). And power train consist of drive train, engine and other parts (Arman Jaya, 2017, Zhenhe Li, 2019). In this work proportional–integral–derivative (PID) controller along with hall effect sensors are used towards speed control of Brushless DC (BLDC) motor as shown in Fig.1.

This paper also deals with braking mechanism (Nicolò Daina, 2017), starting of the BLDC motor, without position sensors (Mei Ying, 2010, D.B. Richardson, 2013). In the literatures, charging infrastructures (Markus Fischer, 2022), additive manufacturing (Dirk Schuhmann, 2022), software models (Namratha Raj, 2021), design and performance analysis

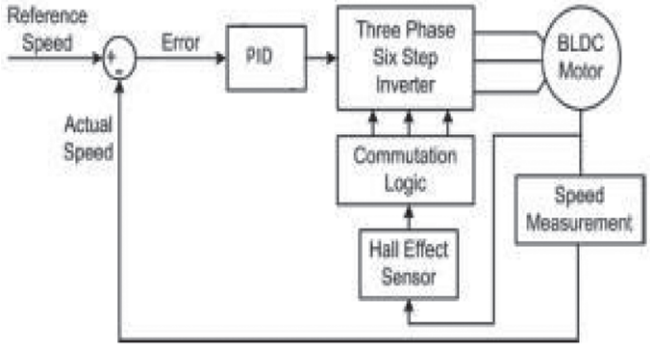

Figure 1: Speed Control of BLDC Motor using PID controller

(Pengwei Wang, 2022), impact of climate (Samuel Hasselwander, 2022), heat balanced gear box (Roland Uerlich, 2022), driver systems (Kiyomoto Kawakami 2007), control methods in EVs (Manabu Omae, 2007, Nobuyoshi Mutoh, 2007), and its developments (L. Andaloro, 2015) has been discussed.

This mono car designed such a way that the user can stop the electric vehicle mechanically by using hand brakes present in the vehicle. The vehicle can be used to carry weights or luggage with the help of carrier provided. It takes minimum parking space and it can easily manoeuvre through traffic. The vehicle is eco-friendly and has zero fuel consumption thereby making it cost effective.

2.0 Methodology

2.1 Working

This vehicle is a BEV (battery operated electric vehicle) which uses rechargeable batteries unlike gasoline that is used in HEV (hybrid electric vehicle). The operational block is shown in the Fig.2.

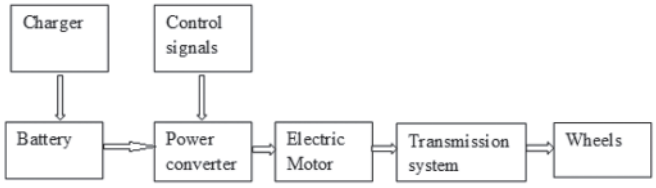

Figure 2: Operational block of an electric vehicle

A key mechanism is used to start the vehicle after which the mechanical movement can be controlled by using an electronic throttle. The throttle engages with the motor and provides power to the vehicle to move forward. The EV is a rear wheel drive that uses transmission chain, so that the mechanical power is transmitted from the motor to the rear wheels. To start the EV, user has to insert the key and switch on the button provided near the right handle bar to initiate the supply to the motor through a battery pack. The motor draws a series and parallel combinations of 7.5Ah and 9Ah batteries, which gives a riding range of 5-8km per unit charge. The speed of the vehicle can be varied conveniently by using a throttle mechanism provided in the handle bar. Throttle, which is connected to the controller helps in varying the speed of the vehicle. The controller is also connected to the ignition switch, headlight and motor through the battery to facilitate the electric displacement. The controller thereby provides acceleration and helps in braking as well.

The complete controller connection for electrical operation of EV is shown in Fig.3.

Figure 3: Complete controller connections for electrical operation of EV

The controller, battery and motor connections in the form of a block diagram are as shown in Fig.4.

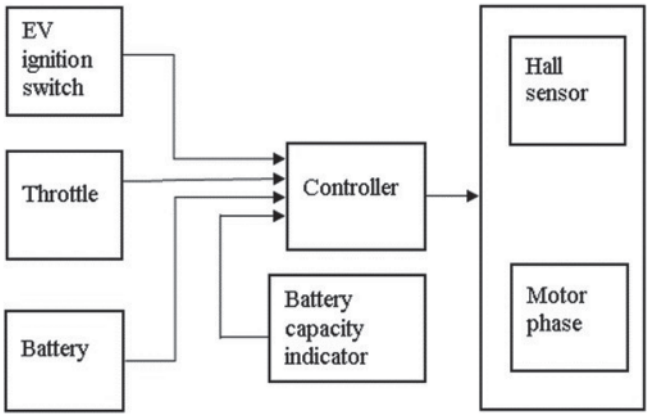

Figure 4: Controller connection block diagram

2.2 Braking System Mechanism

Braking depends mainly on friction to convert kinetic energy to heat energy and stop the vehicle. The drum brakes are used as rear brakes which act as a braking surface on the wheel side. The wheel hub is the part to which wheel and brake drum are attached that serves as a glue between the tire and the axle. The hold down spring holds the brakes to the back plate while the retaining spring retains the spring towards its resting position. The Fig.5 shows braking mechanism of EV for the disabled people.

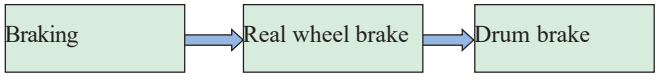

Figure 5: Braking mechanism of electric vehicle for the disabled people

3.0 Design of Electric Vehicle

Electric vehicle for differently abled (movement disabled) people is a specially designed EV which can directly be driven using a wheelchair. The entire framework is made up of mild steel (M.S). Mild steel contains carbon, silicon, manganese, sulphur and phosphorus. Because of its material properties and relatively low price it is most commonly used and acceptable to many applications. This EV incorporates a ramp with thin iron rods attached in the form of tracks which helps the person sitting in the wheelchair to get inside the vehicle without any difficulty. The ramp is placed at the rear side of vehicle thus acting as a rear door. Unlike other automobiles which consists of steering wheel and leg operated brakes, this EV consists of handle bar with accelerating throttle and hand operated brakes for ease controlling by movement disabled person. The vehicle is driven by a BLDC motor powered by lead-acid batteries. The components and material list used for designing the EV is shown in Table 1.

Table 1: list of components and materials used for designing the EV

	Name of Parts/ Components	Material	Quantity
1	Frame	Mild steel	1
2	BLDC Motor	-	1
3	Batteries	Lead-Acid	5
4	Chain	Mild steel	1
5	Shaft	Cast iron	1
6	Throttle	-	1
7	Ramp	Mild steel	1
8	Wheels	Rubber	4
9	Drum brakes	Cast iron	1

3.1 Initial CAD Design of the Vehicle

The metal framework of the vehicle was preceded by designing a basic model of the framework in the software AutoCAD. The entire framework of the EV model in 2 Dimensional and 3 Dimensinal designed in AutoCAD is shown in Figs.6 and 7, (measurements unit-inches)

3.2 Design Specification

The following are the design consideration made for the vehicle:

- Gross vehicle weight (M) = 200Kg
- Speed (N) = 25 Kmph
- Radius of the wheel (R) = 0.2m
- Efficiency (η) = 80 %

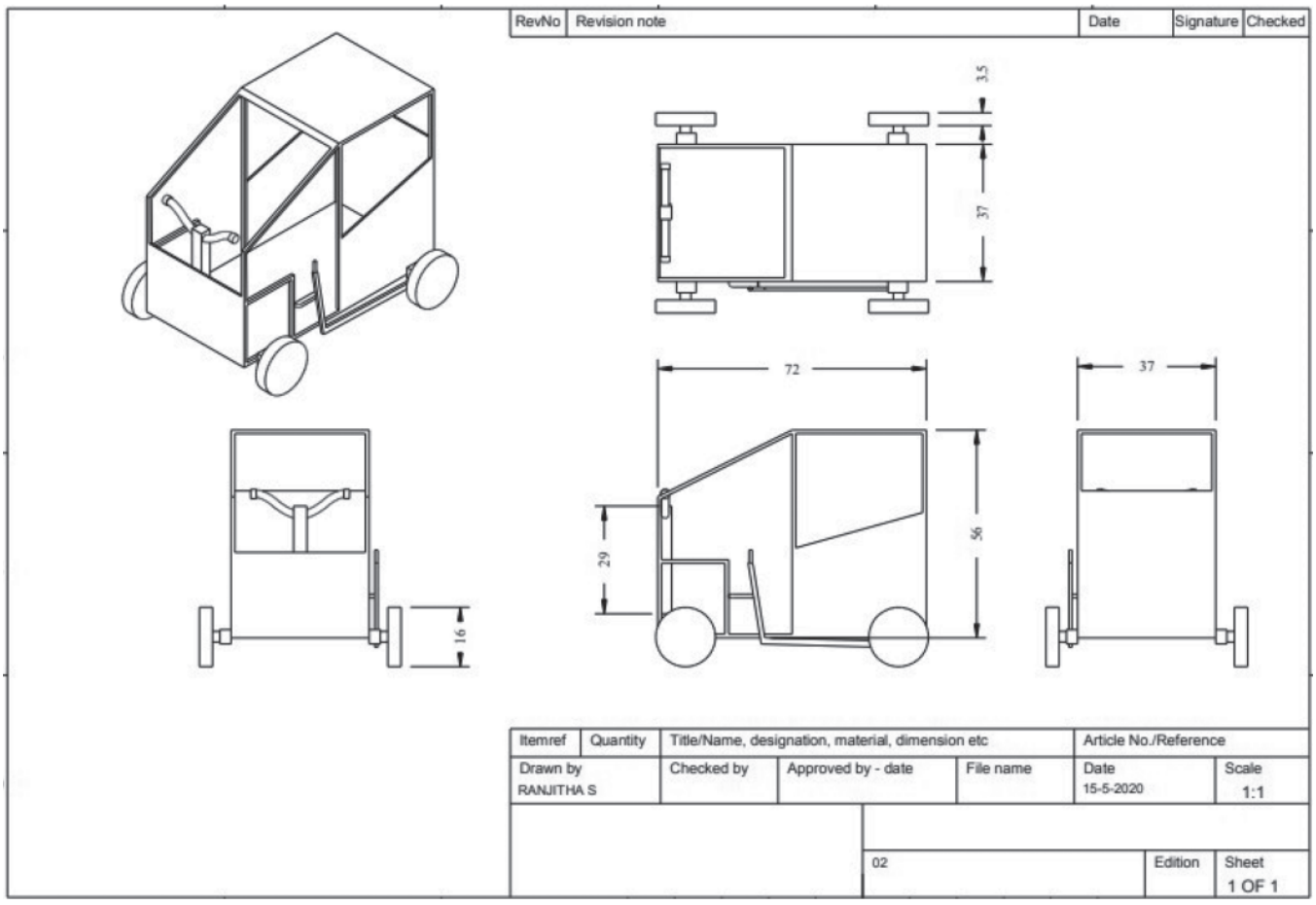

Figure 6: 2 Dimensional frame of the model

- Acceleration due to gravity (g) = 9.8 m/s^2
- Length of the vehicle (L) =1.5m
- Width of the vehicle (B) =0.7m
- Drag coefficient (Cd) =0.8
- Coefficient of rolling resistance (Rr) = 0.0153N
- Air density (Ad) = 1.202Kg/m^3

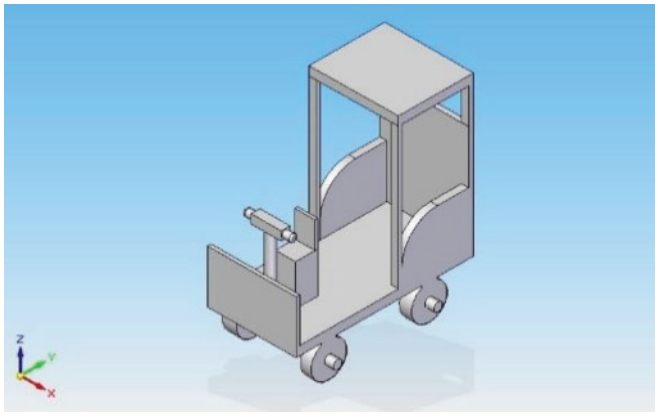

Figure 7: complete 3 Dimensional frame of the model

3.3 Design and Calculation

- For designing the structure, the following parameters were calculated
- Linear distance travelled (D) = 2×p×R = 1.27m ... (1)
- Speed in rotation per minute (rpm) = Total distance covered per hour/linear distance covered = 25000/60×1.27 = 328.08 rpm ... (2)
- Velocity in metre per second (V) = 25×5/18=6.94m/s ... (3)
- Output of motor = (M×g×V×Rr) + (Cd×Ad×area×V3). = 530W ... (4)

3.4 Detailed Structure of the EV

The structure of our EV can be divided into the following main components,

3.4.1 Wheel

The wheels are integrated structural component of the electric vehicle. The electrical vehicle incorporates four-wheel structure of same diameter to enable stability and enhance the

design of overall structure.

The wheel has following dimensions:

- Rim diameter =16 inches
- Wheel diameter = 10 inches

The power generated is delivered to rear wheel which helps the vehicle to move forward. The material used for the wheel is Al Alloy. The wheel is shown in Fig.8 and base in Fig.9.

Figure 8: Wheel used in EV

Figure 9: Electric vehicle's base

Figure 11: Back view of ramp

Base: The base of the vehicle is built using the concept of ladder chassis having a ground clearance of 16 inches. The base is built using MS Steel, having a total weight of 22kg and has a dimension of 60×26 inches. The base is joined using arc welding technique. The approximate height of the vehicle will be 5 feet from the base. The base will have the capacity to withhold the weight up to 200 kg.

The ladder chassis model is used so that the body and the roof can be built over it and it can also be easily replaceable which will make the base light weight and affordable.

Ramp: The specialty of this EV is that movement disabled person can drive it by using his wheelchair. In order for wheelchair to get inside the EV we have built a ramp with thin iron rods attached to it which acts as tracks at the rear side of EV. This ramp also acts as a door. The side and back view of the ramp is shown in Figs.10 and 11.

The base consists of chassis framework, metal plank. The ladder type chassis framework was built using two longitudinal hollow MS Steel of 10×10 mm that runs the entire length of the vehicle with provided cross members made up of hollow MS Steel of 10×10 mm provided to hold the rails in place.

3.4.2 Brake

The drum brakes are usually installed at rear wheels. The drum brake system is used for smooth control of the vehicle is shown in Fig.12.

The brake shoe is allowed to expand in both the direction. As the brake lining of shoe touches the inner surface of the drum, friction is generated in between the brake shoe and drum and stops the vehicle from moving.

Figure 10: Side view of the ramp

Figure 12: Drum Brake used in EV

Since the brakes need to be applied through hands, the braking system installed is a different from any other braking system. A handle is placed at left side of the vehicle which is connected to left end rear wheel via iron bar. The handle can be pulled backward or pushed forward for applying brakes.

The brakes installed in our EV is shown in Figs.13 and 14.

3.5 Assembly of the Framework

The entire framework of the EV model can be described in the step wise manner as follows:

Step 1 includes building of the chassis framework as shown in the Fig.15 (Metal used – Mild steel). The base framework was designed to have the following dimensions.

Length - 1500mm, Breath - 600mm

Step 2 includes obtaining a steering head, throttle, charging socket, along with other miscellaneous second hand components as shown in the Fig.15.

Step 3 includes placing of motor, providing chain drive arrangement, assembling of wheels and other parts as shown in the Fig.16.

Hand throttle, braking system, rail arrangement for movement of wheelchair, rear door arrangements are done in step 4 as shown in the Fig.17.

Initial outer framework assembly based on the decided dimensions was designed in step 5 as shown in the Fig.18.

Figure 13: Braking system

Figure 14: Braking system

4.0 Results and Discussion

The model incorporates an electric motor, hand operated brakes, battery and controller mechanism which enables the operation of an electric vehicle.

Ramp system was strategically incorporated in the EV, the ramp system consists of thin mild steel rods welded to the it, in the form of tracks which helps the person sitting in the wheelchair to get

Figure 15: Ladder chassis, Throttle, steering head, BLDC motor

Figure 16: Chain drive system

Figure 17: Building the body

Figure 18: Assembly of EV

inside the vehicle without any difficulty. The ramp also acts a door in the rear side of the vehicle.

In accordance with the design, it provides ease of movement of paraplegic person which helps them travel for short distances. From the results obtained so far, we can infer that this model is successful in providing the joy of movement for paraplegic people to move independently from one place to another enabling the user to travel at any time of the day. This EV is designed to carry 150 kgs including human weight. The dimension of the vehicle is 1.5m × 0.7m. The speed limit is 25 kmph.

5.0 Conclusions

A mono seated electric vehicle for a movement disabled person is designed with the following main applications:

- Easily operated by a paraplegic person to commute to nearby places.
- A cost effective, eco-friendly and efficient transport system.

This is designed such a way that wheel chair can easily fit in and also compact structure increases its utility even in narrow roads enables to even shop for daily needs. The speed limit is chosen such that this specially abled people move hassle free without license.

Future Scope

This type of vehicle can enable movement disable people to lead a normal independent life. Therefore, this vehicle can be manufactured and commercially available.

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